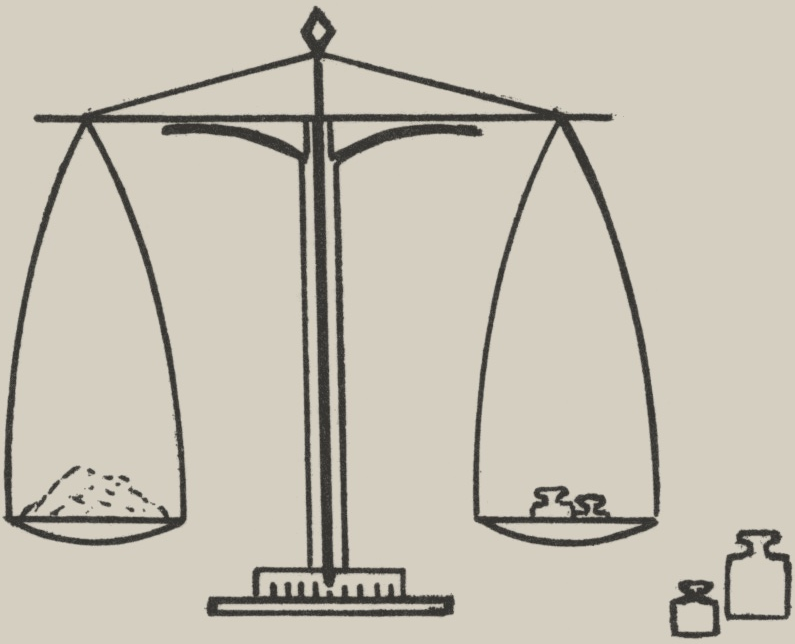
THINGS of science



MEASUREMENT

Created and distributed without profit by Science Service, Inc., 1719 N Street, N.W., Washington, D. C. 20036. E. G. Sherburne, Jr., Director. Ruby Yoshioka, Editor.

Copyright © 1971 by Science Service, Inc.

MEASUREMENT

One of the most important systems we use in our daily lives is that of standardized measurement. An orderly society depends upon a controlled measurement system—a system of units of weights and measures, its standardization and its administration.

Without it, we could not go to the store and buy a pound of sugar, a quart of milk or a yard of goods and be sure we obtained the exact amount we paid for. Scientists would not be able to send men to the moon nor could a physician prescribe medicines with any degree of safety.

Although practically everything we utilize has been measured in some way before it reaches our hands—in length, width, weight or volume—most of us do not stop to think what measurement is, nor do we realize how truly complex it is.

It took thousands of years for man to develop the various types of measurement now in use and to standardize them. The first idea of measurement probably developed in the very early days of man's history, even before he learned to count and keep numerical track of his livestock or other possessions.

As man gradually gave up his nomadic way of living and settled down to farming or trading, he started to build homes, to barter and claim goods and land. Thus a need arose for reasonably accurate standards of measurement.

Through the ages, each local primitive group or society, and later country, developed its own system of measurements, and hundreds of units came into existence. By the Middle Ages they numbered into many thousands. As long as people lived within their own communities, this chaotic condition did not matter too much. Traders who traveled from country to country could learn the different units necessary to transact their business.

However, with increasing communications between countries, the importance for standardization of measurement became more and more evident, especially among scientists whose work is essentially international. As a result, the French scientists, then called philosophers, at the end of the 18th century developed the metric system which was instituted in France during the French Revolution. Since that time, its use has spread worldwide, not only among scientists, but as a standard of measurement for most countries.

With the materials in this unit, you will learn some of the basic principles of measurement and compare the metric system with the U. S. Customary System.

First identify your materials.

BUCKSHOT—Four one-fourth-inch diameter buckshot to be used as weight standards.

LEAD SINKER—For use in the construction of a weighing scale.

PAPER CUPS—To be used as weighing pans.

WIRE—For use in constructing a balance.

DIAGRAM SHEET—Containing a centimeter-inch rule and a centimeter rule.

WHAT IS MEASUREMENT?

The principal types of measurement most commonly used as tools in our daily lives are length, weight and volume.

When man first conceived the idea of measuring length, parts of the body were used as units, such as the foot, length of the arm from the elbow to finger tips (cubit), the distance from the tip of the thumb to the tip of the little finger of an open hand (span) and arm's length. Such units were useful to a point, but since the sizes of humans vary, a foot could mean

one length to one person and another to another.

Experiment 1. Take a yardstick or tape measure and measure the length of the arm of several adults from the elbow to the finger tips. Note how the cubit as originally used, varies from person to person. The cubit today is equal to approximately 18 inches.

Now measure the length of the foot of several adults. Here, too, you will find a wide variation.

Because of these differences you can see that some form of standardization became necessary to provide a peaceful means of trade.

Still, some primitive methods of measurement in spite of standardizations persist to this day. For example, the yard is a derivative of the ell, the distance from the tips of the finger of the outstretched arm to the center of the chin, a former British unit. One sees women to this day using a modification of the original ell (distance from the tip of the nose to the thumb of the outstretched arm) to estimate the yardage of cloth (the standard ell is 45 inches). Can you think of other examples?

Early units of weight were not derived

from parts of the body, but were based on objects found in nature. Historians believe that the first unit of weight was the stone. A man was said to weigh so many stones (the standardized stone is equal to 14 pounds). Seeds of grains, especially wheat and rice, and other seeds, because they are fairly consistent in size, were also used as bases for units of weight. The jeweler's carat, for example, is based on the weight of a caromb seed. This unit varied widely from place to place and was finally standardized in the United States to a metric carat weighing 200 milligrams.

The term grain is still employed in the American system as a unit of weight. Thus, one avoirdupois pound weighs 7,000 grains, while the American dollar is equal in value to 15.238 grains of gold in the International Monetary System.

The oldest unit of weight made by man was the shekel believed to have been originated by the Sumerians. The shekel varied in weight depending on the country from 126 to 252 grains.

The third important measurement is that of capacity or volume—the space a liquid, solid or other substance occupies. Ancient man probably first used his cupped hands to measure volume. Egg shells and gourds

were also used. With the development of pottery and basket weaving, measures of capacity gradually became standardized within various countries for both liquid and dry measures.

Today, the standard pint, quart, gallon, bushel and barrel are familiar units of volume. The teaspoon, tablespoon and cup, although they have been defined, have not been, strictly speaking, standardized.

Experiment 2. Compare various commercially available household measuring utensils to show this is so.

In the United States, two separate systems of measurement are still in use—the U. S. Customary System (based on the English system) and the metric system.

The U. S. Customary System—pounds, ounces, inches, yards, acres, etc.—is the one most used in our daily living, while the metric system—meters, grams and liters—is still used primarily by scientists.

THE METRIC SYSTEM

The metric system was developed with a great deal of study and thought. It is based on the decimal system or units of 10, simplifying arithmetical calculations and minimizing the use of fractions.

The French originally defined the meter as one ten-millionth of one quarter of the distance around the earth. However, they later discovered that their measurement of the earth was not precise. Instead of making changes in the meter, already in use, it was decided that the meter would remain the same and be defined as the distance between two lines cut on the primary meter bar which is housed at the International Bureau of Weights and Measures. The meter is now defined in terms of wavelengths of light. Prototypes of the meter bar and kilogram made of platinum-iridium are kept in the standards vault at the National Bureau of Standards in Gaithersburg, Maryland.

The modern metric system adopted by an international conference on weights and measures in 1960 is known as the International System of Units or SI (from Le Systeme International d'Unites).

At first chiefly a tool for scientists, the advantages of the metric system for general use were recognized and now virtually every country has adopted it or is in the process of converting to the metric system. The United States is the only major country which has not yet decided to go completely metric or metricate.

Because the U. S. Customary System grew along with man in his development, much of it is based on tradition and the units are carryovers from prehistoric times. There are more than 80 units of weights and measures commonly used in the United States today to express length, weight and volume.

In the metric system, on the other hand, only two basic units are needed for these measurements—meter for length and kilogram for mass (and weight). The liter commonly used as a unit of volume is derived from the unit of length (1 liter= 1.000 cubic centimeters). The International System includes four other basic units —for time, temperature, electric current and luminous intensity. All other SI units of measurement are derived from the above six.

Experiment 3. Cut out the centimeter-inch rule (A), and paste it on a cardboard of equal length and width. Note that 12 inches is equal to just short of 30½ centimeters (30.48 cm.).

The inches are divided into eighths and sixteenths, while the centimeter is divided into tenths, a much easier number to handle mathematically.

In the International System there is only

PREFIXES FOR ALL SI UNITS

Multiples and Submultiples	*Pre-fixes*	*Sym-bols*
1,000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
10 = 10^{1}	deka	da
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

Table 1

one unit for each type of measurement. To express multiples and submultiples of the units, whether meters, grams or liters, standard prefixes that apply to all units are used (Table 1).

Thus 1,000 meters is one kilometer; 100 grams, one hectogram; one decimeter, 1/10 of a meter, and one centigram, 1/100 of a gram. One kilometer equals 10 hectometers, 100 dekameters or 1,000 meters.

Likewise, one meter is equal to 10 decimeters, 100 centimeters or 1,000 millimeters.

Set up similar scales for grams and liters.

Experiment 4. Using the base 10, calculations in the metric system are simple. To change larger units to smaller units, say 2.5 grams to milligrams, the decimal is simply moved three places to the right to obtain 2,500 milligrams (obtained by multiplying 2.5 x 1,000).

You can try these sample problems. How many grams in 3.5 kilograms? How many meters do 10 decimeters make? How many milliliters are there in 1.5 liters?

Note the ease with which you can convert decimeters to meters, milligrams to grams, and milliliters to liters.

Experiment 5. Now find how many ounces there are in 2.5 pounds. In the United States, three systems of weight are in use—avoirdupois, troy and apothecaries'. Avoirdupois is the commercial weight, or the one used in weighing sugar, flour and other commodities. Troy weight is used for weighing precious metals and gems and the apothecaries' units for pharmaceutical products.

There are 16 ounces in an avoirdupois

pound. Therefore, to solve your problem, you would multiply 16 x 2.5. But both the troy pound and apothecaries' pound contain only 12 ounces, so depending upon the pound system being used, the number of ounces in 2.5 pounds will differ. The weight of the ounce is the same in the troy and apothecaries' pounds, but is less in the avoirdupois pound. Therefore, the total weight of 2.5 pounds will also be different.

The weight of the grain has been standardized and is the same in all three systems. The avoirdupois pound weighs 7,000 grains while in the troy and apothecaries' systems, the pound is equal to 5,760 grains.

How much simpler it would be to have a single system of weights!

Experiment 6. Distances are measured in kilometers in the metric system, whereas in the U. S. Customary System they are measured in miles, rods, yards, feet and inches.

If you were asked, how many meters there are in five kilometers, the answer would simply be 5 x 1,000 meters.

However, if you were asked how many yards there are in five miles, your problem would be quite different. Unless you have memorized the figure, 5,280 feet per mile,

you would have to look it up to arrive at the correct answer (5,280 ÷ 3) x 5 yards.

Experiment 7. Now find how many fluid ounces there are in 2.5 quarts. Four fluid ounces equal one gill, four gills make one pint and two pints equal one quart. Therefore, in order to find the number of fluid ounces in 2.5 quarts, you would multiply 4 x 4 x 2 x 2.5 to get 80 fluid ounces.

To find how many cubic centimeters in 2.5 liters, all you would need to do is move the decimal point to obtain 2,500 (or 2.5 x 1,000).

The great simplicity of the metric system as compared to the U. S. Customary System becomes obvious as you do such calculations.

The total adoption of the metric system by legislation has been bypassed by Congress so far. A three-year study is now being conducted by the National Bureau of Standards under the Metric Study Act of 1968 to study the feasibility of complete metrication.

There are many arguments for and against going metric. But by educating the public and introducing the metric system early in the school grades, people could be taught to think in terms of meters,

grams and liters instead of feet, pounds and quarts and to visualize these measurements. The teaching of arithmetic in the elementary grades would be greatly simplified and the memorization of the many unrelated units would become unnecessary.

Experiment 8. Take your centimeter-inch rule and measure various objects. Convert centimeter lengths into meters and inch lengths into yards. Which is more quickly and easily done?

Scientists have long ago seen the advantages of the metric system and almost all measurements in laboratories are made using these units. The metric system is also readily reducible to microscopic measurements by simply moving the decimal point, another advantage. Thus a micron is 39.37 millionths of an inch or 0.001 millimeter. There is no question as to which figure is easier to work with.

In international exchange of scientific information, the metric system allows all scientists to meet on a common ground without the necessity of cumbersome conversions from one system to another.

Because of its practicality and universality, the metric system will no doubt be eventually accepted in the U. S., but until

then we will be struggling with how many links make a foot, how many gallons there are in a barrel or how many square meters there are in 16 square rods.

WEIGHT

The weight of any object is defined as the force of the gravitational attraction for that object.

Oftentimes the mass of a body is confused with the weight. The mass of any object is the amount of matter contained in that object, while the weight is a force. The mass of a body always remains the same while the weight changes with changes in gravitational pull.

Since the weight of an object is determined by the force of the gravitational attraction exerted on it, its weight depends upon its distance from the center of the earth. An object weighs more at sea level than at the top of a high mountain because the force of gravity on it decreases as its distance from the center of the earth increases.

The greater the mass of a substance, the greater the gravitational pull on the object. Therefore, the larger and denser an object the heavier it is.

Because the weight of a body changes

from place to place, an absolute force unit that would always remain constant had to be devised. Scientists established the newton as an absolute unit of force.

One of the earliest ways in which man measured weight was by the use of a balance, an instrument that utilizes the force of gravity.

There are several types of balances that developed through the ages, the most universally used of these being the equal-arm beam balance and unequal-arm balances of the steelyard type.

BEAM BALANCE

The beam balance is believed to be the earliest type of weighing scale designed by man. It consists of a rod or beam with a fulcrum at its midpoint and a pan or basket suspended at each end. The weights are held in one pan and the material to be weighed is placed in the other. When the balance is in complete equilibrium and the beam is horizontal, then the load is equal to the weights.

In the earliest types of the beam balance, the beam was supported from below with a finger or upright support acting as the fulcrum. The beam balance, although many designs were inexact, was widely

used and many types existed.

Experiment 9. You can make a simple beam balance with two soda straws, three pins and two pieces of wire.

Obtain two sturdy drinking straws and place them side by side. Insert a pin across each end of both straws, about a quarter of an inch from the ends, and also across the exact center of the two straws.

Push the two straws about one-fourth of an inch apart and then suspend the structure from an upright support. To make the support, use a piece of stiff cardboard about one inch wide and ten inches long. Cut a small groove in the center of one end of the cardboard and then stand it on the other end on a base made with a rectangular piece of cardboard or wood about 4 x 5 inches in size (Fig. 1).

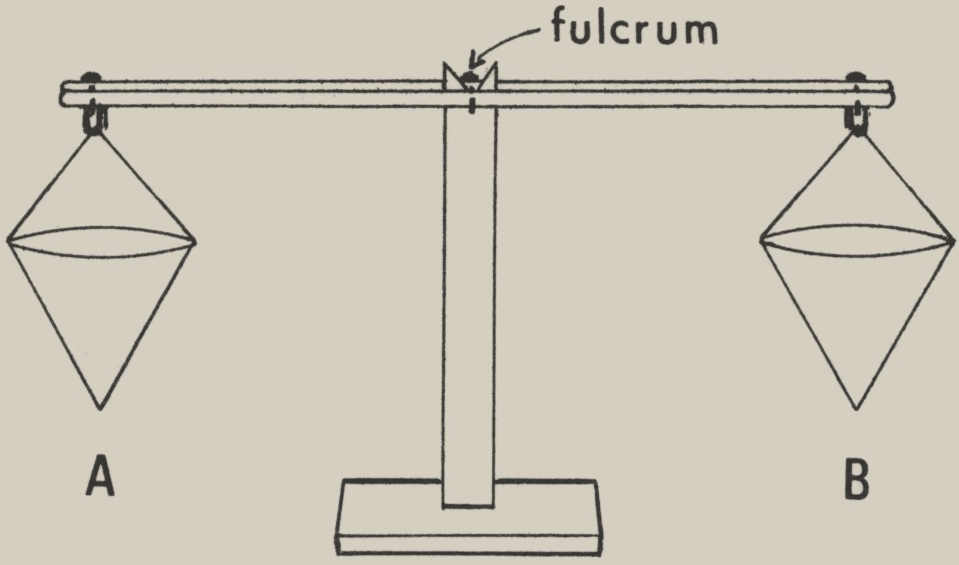


Fig. 1

Fig. 2

Be sure the support is exactly perpendicular to the base. Place the center pin into the groove and you have your balance. Check to see that the beam is exactly level.

Cut two 2½-inch lengths from your wire and bend them into loops about ¾ inch long (Fig. 2).

Insert the loops over the pins at the ends of the beam. Pass threads about 8 inches long through opposite sides of each of the cups, about ¼ inch from the rim to form handles.

Hang the cups from the wire loops (Fig. 1). Check again to see that the beam is level. If it is not exactly horizontal and one side hangs lower than the other, adjust the center pin.

Experiment 10. Place a teaspoonful of sugar in one pan and a teaspoonful of salt in the other. Does the beam remain horizontal? If so, it means that the two weigh exactly the same. If not, how much

more of the lighter material do you have to add to bring the balance into equilibrium again?

Unless standardized weights are used, the beam balance simply compares the weights of two substances. Thus, to make the beam balance truly functional, objects must be counterbalanced with exact weights.

Experiment 11. For standards, you may use the buckshot in your unit, since the shot are made in such a way that those of the same diameter are all just about equal in weight. Each shot in your unit weighs about 1/19 of an ounce or 1.5 grams.

Empty the two cups of their contents.

Using your beam balance check to see if the pieces of shot in your unit are all about the same in weight. To do this, place a shot in each cup. Do they balance each other? Add a second shot to each cup. Does the balance remain in equilibrium?

Experiment 12. Empty the cups. Now place one buckshot in cup A (Fig. 1) and gradually add salt to cup B on the right until the beam is horizontal again. Now measure the volume of the salt. The quantity of salt measured is equal to approximately 1/19 of an ounce or 1.5 grams.

Empty cup B. Place some flour in it. Note how much is required to balance the scales again. Compare this quantity with that of salt.

From your results, you can see that equal weight does not necessarily mean equal volume.

You can measure any quantity of substance using the buckshot up to the capacity of your beam balance. Just as the early Babylonians may have said an object weighed so many stones, you may say a tablespoon of flour weighs so many pieces of shot. But if you wish the rest of the world to understand what you mean, you will have to convert these weights into familiar units such as grams or ounces.

Standards of measurements can be based on any premise desired, and anyone can start a system, but to be functional it must be accepted by all the people concerned.

Experiment 13. Make another beam balance. This time cut a piece of strong cardboard 1.2 centimeters, or about one-half inch wide, and 30 centimeters long. Cut out the centimeter rule (B) from your diagram sheet and paste it on one side of the cardboard strip to form the beam of the balance. Suspend the beam from the center (at 15 cm.) with a strong thread

about 10 inches long from a nail or other projection where it can hang freely. You now have a beam balance with a scale.

When we weigh an object on a beam balance, the effect of the pull of the earth on the object is just balanced by the pull of gravity on the weights. When the two are in equilibrium, then the object is equal in weight to the units of weights used.

If the same beam balance with the same weights and load were taken to a mountain top where the gravitational pull is less, the scales would still balance since the force of the gravitational pull on both the weights and the load will be reduced an equal amount. Thus, measurements with a beam balance are not affected by the position on the earth.

However, this would not be true for a spring balance. When an object is weighed with a spring balance, the gravitational pull stretches the coiled spring of the balance. This stretching continues until the opposing forces of the spring and gravity are in equilibrium. Therefore, on a high mountain top, the spring would not be stretched as much and the weight registered would be less. The spring balance, therefore, can be less accurate than a beam balance.

Experiment 14. Remove the paper

cups and wire loops from your soda straw beam balance. Insert the wire loops with cups suspended over the arms of the balance you have just made. Place them about two centimeters from each end. Be sure the balance is in equilibrium. If they do not balance exactly, add bits of paper to the cup on the lighter side until the beam is horizontal.

Place a shot in the cup on the left (A). Move the cup along the beam until it reaches a point where it exactly balances the empty cup again. Place a shot in cup B. Can you restore equilibrium again? How?

The beam balance is essentially a lever that rotates about a point called the fulcrum. The fulcrum in this case is the point at which the central thread is attached, or the midpoint of the beam.

If you place a lead weight in one of the cups and one in the other, the effort force remains equal to the resistance force since the mass of the two pieces of shot are the same and the lever stays in balance.

Experiment 15. When a lever is used as a weighing instrument, its balance depends upon two things—the amount of force that is applied (the weight) and its lever arm (the length). If the loads

are not equal in the two pans, the lever will turn in the direction of the heavier arm. This turning is due to the moment of force which is defined as the force times the lever arm, or

$$M = F \times L$$

Place your beam balance in equilibrium with one lead shot in cup A and cup B empty. Now place a second lead shot in cup A. Push cup A toward the center until the balance is in equilibrium again.

Now, the effort of the cup and pieces of shot balance the resistance of the empty paper cup. Next place a shot in cup B. In which direction must you move cup A to again obtain equilibrium in the balance?

When a lever is balanced, the moment of force acting on the weight in cup A equals that of the force acting on the load in cup B, or

$$A \times L_1 = B \times L_2$$

Now place another shot in cup A. Note how much you must move the cup toward the center to again obtain equilibrium (Fig. 3).

(Fig. 3 is purely diagrammatic and cup A in your experiment will not necessarily be three divisions from the fulcrum as in the drawing.)

If you removed cup A, the lever would turn around the fulcrum in a clockwise direction. Show that this is so. Therefore, the moment of force of cup B is a clockwise moment.

If cup A is replaced and cup B is removed, the moment of force of A would be counterclockwise about the fulcrum.

Therefore, in general, when a beam balance is in equilibrium, the sum of the clockwise moments is equal to the sum of the counterclockwise moments about the fulcrum.

This principle is also used in the type of scale known as the steelyard.

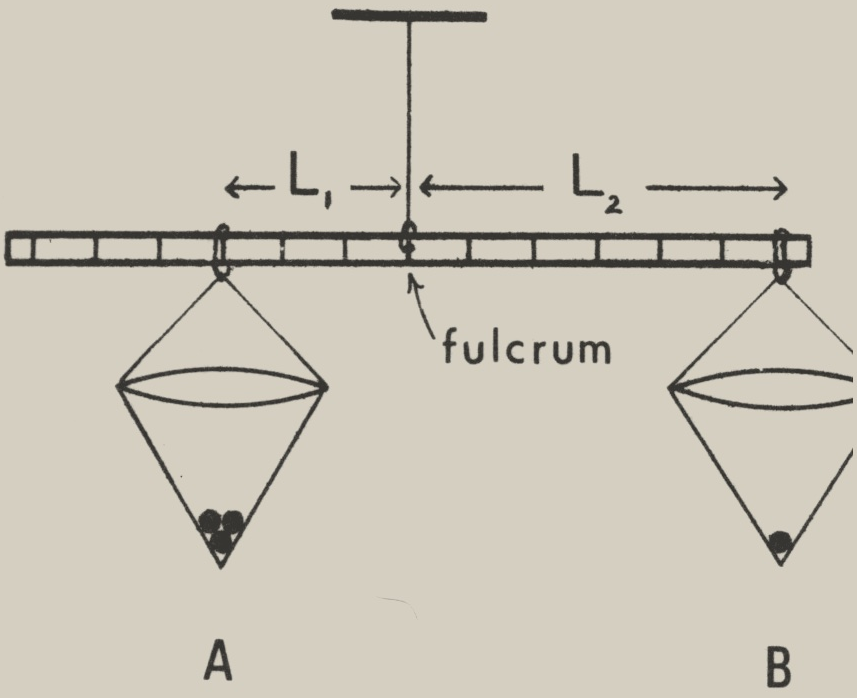


Fig. 3

STEELYARD

Steelyards are weighing scales using a beam with unequal arms. It has a permanent fulcrum, a weighing pan attached to the shorter arm and a movable weight or counterpoise suspended from the longer arm. When the counterpoise is at the fulcrum, the empty scale is in equilibrium.

It is believed that the Romans invented this widely used balance and that it existed more than 2,000 years ago. There were steelyards of all types and sizes depending upon the size and weight of the load being considered. Some were made with beams of wood, others with metal or even ivory.

There were also many types of counterpoises which were moved back and forth along the beam until the scale was balanced. Some were simple geometric shapes, while others were made in forms of animals or figures, small works of art.

The weight of the object in the pan at the left could be observed from the markings on the long beam of the scale.

Our modern platform scales in which the platform for loads rests on the lever is a steelyard type. The counterpoise is moved along a lever arm on which the weights are indicated.

Experiment 16. Make a steelyard using the lead sinker as the counterpoise (Fig. 4).

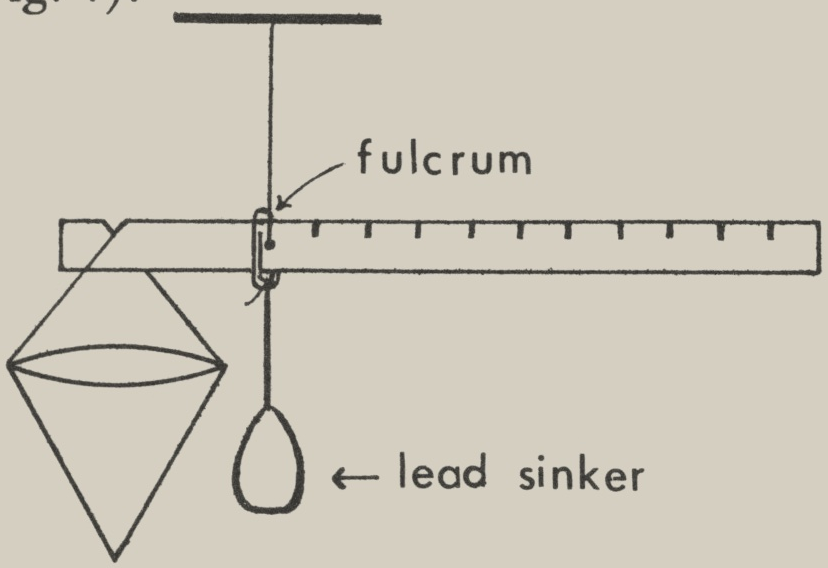


Fig. 4

Cut a length of cardboard about ½ inch wide and 8 to 10 inches long. Paste over on one side the strip of white paper (C) remaining from your Diagram Sheet.

One-half inch from the left edge, make a small notch and suspend one of the paper cups from this point.

Next take a length of thread about 8 inches long and loop it over the cardboard beam, securing it loosely at first about 2 inches from the notch. Pull a thread about 8 inches long through the hole in the sinker. If the hole is very small you can enlarge it a little with a straight pin. Tie a large knot at the end of the thread so

that the sinker will be suspended by the thread. Make another wire loop and tie the free end of the thread to it. Pass the wire loop over the beam. This is the counterpoise for your steelyard.

Place the counterpoise at the fulcrum and balance the scale adjusting the position of the fulcrum and sinker until a point of equilibrium is reached. If necessary, shorten the long arm of the beam slightly to obtain equilibrium. The counterpoise should hang freely exactly below the fulcrum when the scale is balanced. When you find this point, tighten the thread at the fulcrum so that it will not slip.

Now place one buckshot in the paper cup, gently so that you will not upset the balance and move the counterpoise to the right until the steelyard is again in equilibrium. Draw a vertical line on the arm at this point. This will indicate the weight of one shot.

Place another shot in the cup and push the counterpoise to the right again until equilibrium is reached. Mark this point with another line. Repeat this with the other two shot adding one at a time. Now you have four points on your scale. Number them 1, 2, 3 and 4. Since the pieces of shot all weigh about the same, these divi-

sions will be about equal in width, each representing 1.5 grams or 1/19 ounce.

Measure these divisions and calibrate the rest of the beam arm by marking off the average length for each 1.5 gram weight. Now you will be able to weigh small items using this steelyard and know their approximate weights in grams or ounces. Weigh a few paper clips, cubes of sugar or other small objects.

Calculate their weights in grams and ounces.

Be sure not to overload your steelyard which is fairly delicate being made of cardboard. If you are adept at wood carving, you can design steelyards similar to those used in early times. Pictures of these can be found in one of the reference books listed at the end of this booklet.

A scale similar to the steelyard is the bismar. In this instrument, the counterpoise is immovable and the fulcrum is moved to balance the weight which hangs from the end of the longer arm of the beam. The correct weight is read on the beam from the position of the fulcrum. You may wish to construct a bismar.

The importance of scales in the cultural history of man since ancient times is expressed by their use as a symbol of justice.

Justice and equality are traditionally represented by a balance held in equilibrium.

VOLUME

Units of volume in the International System are derived directly from units of length. For example, the standard metric unit of capacity is one cubic decimeter ($1{,}000cm^3$) or one liter. But in the U.S. Customary System units of volume are an outgrowth of those developed independently by ancient man as the need arose with no relation to length or weight, resulting in the many miscellaneous units.

However, they have now been standardized to metric units in equivalent cubic centimeters, milliliters or liters. In the metric system, one cubic centimeter, or one milliliter, is the volume occupied by one gram of water at 4°C.

By this standard, one liquid pint is equal to 0.473 liters. It also equals 4 gills and 28.875 cubic inches.

Volume, therefore, can be determined by either the weight of the substance or by the amount of space it occupies.

We usually purchase milk, vinegar, salad oil, gasoline and other liquid substances in pints, quarts or gallons, that is by volume, rather than by weight, and

solid materials, such as butter, flour, sugar and salt by ounces and pounds.

If you will look carefully the next time you go grocery shopping, you will find that on some packages, the equivalent weight is given in grams or milligrams.

The liter and the milliliter are the most used metric units for measuring volume in countries that use the metric system. Gasoline, milk and other liquids are sold in liters and centiliters. One liter is slightly more than one quart, 1.057 quarts.

Experiment 17. Obtain two small medicine bottles or vials and suspend them from your beam balance. When they are in equilibrium, place one lead shot in one bottle. To the other add water a little at a time until the scale is balanced.

Since one cubic centimeter of water weighs close to one gram at room temperature, your weights will give you an idea of how much space up to six milliliters of water will occupy.

Can you estimate the volume of one ounce of water?

From ancient days, standards of measurement have been controlled by the governments of the various nations. In the United States, the National Bureau of Standards has custody of the national

standards.

As you have observed in Experiment 12, equal weight does not necessarily mean equal volume. A cup of feathers would weigh much less than a cup of lead shot.

Therefore, the bushel which is a measure of volume, is also used as a measure of weight. For example, by standardized definition, a bushel of oats is equal to 32 pounds, a bushel of wheat to 60 pounds and a bushel of corn, 56 pounds. This all adds to the confusion of weights and measures as used today.

We live in an age of standardized measurements and take it for granted that a pound is a pound, a bushel of corn is exactly 56 pounds, a gram is a gram and an inch an inch. But it is only through strict government surveillance that this is so.

The development of weights and measures and how intertwined they are in our life today and our cultural background, and the controversy over adopting the metric system is a subject that concerns us all.

If you are interested in reading further on the subject here are some references.

..... cut out label on other side and paste on box .....

THINGS of science MEMBERSHIP

12 monthly experimental kits—$9.50

(Add $1.50 for outside U.S.A. addresses.)

Evolution of Weights and Measures and the Metric System, Hallock and Wade, MacMillan Co., New York.

Prepare Now for a Metric Future, Frank Donovan, Waybright and Talley, New York.

Realm of Measure, Isaac Asimov, Houghton Mifflin Company, Boston, Mass.

Scales and Weights, by Bruno Kisch, Yale University Press, New Haven, Conn.

The Story of Standards, by John Perry, Funk & Wagnalls, New York.

* * *

Copyright © 1971 by Science Service, Inc.

THINGS of science
MEASUREMENT
Science Service Washington, D. C. 20036